

<b>UTILITY PATENT APPLICATION TRANSMITTAL</b> (Only for new nonprovisional applications under 37 CFR 1.53(b))	Attorney Docket No. <b>001552</b>	Total Pages
	First Named Inventor or Application Identifier	
	<b>Tsutomu OOSHIMA</b>	
Check Box, if applicable <input type="checkbox"/> Duplicate	Express Mail Label No.	

APPLICATION ELEMENTS FOR: <b>SEALED BATTERY</b>	ADDRESS TO: Director of Patents and Trademarks BOX PATENT APPLICATIONS Washington, D.C. 20231
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1. ☒ Fee Transmittal Form (Incorporated within this form)  
(Submit an original and a duplicate for fee processing)
2. ☒ Specification Total Pages [12]
3. ☒ Drawing(s) (35 USC 113) Total Sheets [3]
4. ☒ Oath or Declaration Total Pages [2]
  - a. ☒ Newly executed (original)
  - b. ☐ Copy from prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 17 completed).
    - i. ☐ Deletion of Inventor(s)  
Signed statement attached deleting inventor(s) named in prior application,  
see 37 CFR 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation by reference (useable if box 4b is checked)  
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ Microfiche Computer Program (Appendix)
7. ☐ Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
  - a. ☐ Computer Readable Copy
  - b. ☐ Paper Copy (identical to computer copy)
  - c. ☐ Statement Verifying identity of above copies

**ACCOMPANYING APPLICATION PARTS**

8. ☒ Assignment Papers (cover sheet and document(s))
9. ☐ 37 CFR 3.73(b) Statement (when there is an assignee) ☒ Power of Attorney

**UTILITY PATENT  
APPLICATION TRANSMITTAL**

(Only for new nonprovisional applications  
under 37 CFR 1.53(b))

Attorney Docket No. **001552**

First Named Inventor or Application Identifier

**Tsutomu OOSHIMA**

**PAGE 2 OF 3**

10. ☐ English translation Document (if applicable)

11. ☐ Information Disclosure Statement ☐ Copies of IDS Citations

12. ☐ Preliminary Amendment

13. ☒ Return Receipt Postcard (MPEP 503)

14. ☐ Small Entity Status is claimed.

15. ☒ Claim for Convention Priority ☒ [1] Certified copy of Priority Document

- a. Priority of \_\_\_\_\_ application no. \_\_\_\_\_ filed on \_\_\_\_\_ is claimed under 35 USC 119.  
The certified copies/copy have/has been filed in prior application Serial No. \_\_\_\_\_.  
(For Continuing Applications, if applicable).

16. ☐ Other \_\_\_\_\_

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☐ Continuation ☐ Division ☐ Continuation-in-part (CIP) of prior application no. \_\_\_\_/\_\_\_\_

FEE TRANSMITTAL	Number Filed	Number Extra	Rate	Basic . . . Fee
The filing fee is calculated below				\$710.00
Total Claims	4 - 20		x \$18.00	
Independent Claims	1 - 3		x \$80.00	
Multiple Dependent Claims			\$270.00	
Basic Filing Fee				\$710.00
Reduction by 1/2 for small entity				
Fee for recording enclosed Assignment			\$40.00	\$ 40.00
TOTAL				\$ 750.00

UTILITY PATENT  
APPLICATION TRANSMITTAL

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Attorney Docket No.

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Tsutomu OOSHIMA

PAGE 3 OF 3

☒ [XX] A check in the amount of \$ 750.00 is enclosed to cover the filing fee of \$ 710.00 and the assignment recordation fee of \$ 40.00.

☐ [ ] Please charge our Deposit Account No. **01-2340** in the total amount of \_\_\_\_\_ to cover the filing fee and the \_\_\_\_\_ assignment recordation fee. A duplicate of this sheet is attached.

☒ [XX] The Commissioner is hereby authorized to charge payment for any additional filing fees required under 37 CFR 1.16 or credit any overpayment to Deposit Account No. **01-2340**. A duplicate of this sheet is attached.

18. CORRESPONDENCE ADDRESS



23850

PATENT TRADEMARK OFFICE

SUBMITTED BY

Typed or Printed Name Donald W. Hanson

Reg. No. 27,133

Signature

Date: November 27, 2000

DWH/II

## TITLE OF THE INVENTION

### SEALED BATTERY

## BACKGROUND OF THE INVENTION

5       The present invention relates to a rectangular type battery. In particular, the invention relates to a rectangular type battery comprising a positive electrode and a negative electrode laminated on each other with a separator interposed between them, and also to a sealed  
10 battery such as a lithium ion battery.

      In devices and equipment using batteries, a battery accommodating compartment designed in form of rectangular parallelepiped is generally used. When a cylindrical battery is accommodated in the battery accommodating  
15 compartment in form of rectangular parallelepiped, there is a problem in that ineffective volume is increased. Further, diameter of the cylindrical battery is limited by the thickness of the battery accommodating compartment. For this reason, in small-size or thin-walled devices or  
20 equipment, a rectangular type sealed battery with smaller thickness is used instead of a cylindrical type battery.

      In these batteries, capacity of the battery depends on the quantity of active components in the positive electrode and the negative electrode laminated on each other with a  
25 separator interposed between them. The positive and the negative electrodes are produced as follows: A positive electrode active component and a negative electrode active component, each on a belt-like metal base, are coated on

each of a positive electrode current collector and a negative electrode current collector respectively. By increasing the coating thickness of the active components, it is possible to increase electric capacity of the positive electrodes and the negative electrodes.

A battery element is prepared by laminating the positive electrode and the negative electrode on each other via a separator, and this battery element is accommodated in a battery case. When the thickness of active component layers of the positive and the negative electrodes is increased in the battery, the swelling or the expansion of the battery case when the battery is charged is unavoidably increased.

When the swelling of the battery case is increased, there may be difficulties in disposing the battery on the devices or equipment where the battery is used or ineffective space may be increased in order to provide surplus space to cope with the anticipated swelling.

JP-07183010(A) describes a method for manufacturing a rectangular type sealed battery. In this method, a side surface of an external case of the battery in contact with the battery element is designed in recessed form.

However, in a battery with smaller thickness where the side surface is merely depressed, it is difficult to attain sufficient effect.

It is an object of the present invention to provide a rectangular type battery, by which it is possible to prevent swelling or expansion of the side surface of the

battery case caused by swelling of the battery element when the battery is charged, and also to eliminate useless or ineffective space in the battery accommodating compartment.

5

#### SUMMARY OF THE INVENTION

The present invention provides a sealed battery, accommodating a battery element of flat shape, said battery element comprising a positive electrode and a negative electrode being laminated on each other with a separator interposed between them and being wound together, characterized in that a recessed portion is formed on a side surface of a battery case running in parallel to a flat surface of the battery element, said recessed portion having a central axis running in parallel to said flat surface and being positioned on a surface passing through the center of the battery case and running perpendicularly to the surface in parallel to the flat surface of the battery element.

Also, the present invention provides the sealed battery as described above, wherein a vertical wall surface is designed in form of a small curved surface, and said wall surface connecting an end of the recessed portion in form of curved surface on an opening of the battery case with a side surface in parallel to the flat surface of the battery element in the battery case, and a distance from the wall surface to the opening end of the battery is gradually reduced toward the center.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a sealed battery of the present invention;

Fig. 2 is a drawing to explain another example of the sealed battery of the present invention;

Fig. 3 is a schematical drawing of a sealed battery of an embodiment of the invention;

Fig. 4 is a diagram to explain thickness of the battery; and

Fig. 5 is a diagram to explain thickness of the battery.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

A sealed battery according to the present invention comprises a battery element in flat shape. A positive electrode and a negative electrode are laminated on each other with a separator interposed between them. This is wound up to prepare a battery element in flat shape, and these battery element is accommodated in a sealed battery. It has been found in this type of battery that the battery case is deformed due to swelling or expansion of the flat surface in perpendicular direction when the battery is charged, and this deformation can be suppressed or eliminated by forming a recessed portion on wall surface of the battery case to a specific shape.

Specifically, if a recessed portion with curved bottom surface is formed on a side surface of the battery case facing to the flat surface of a battery element, the

swelling or expansion of the battery case can be effectively suppressed when the battery is charged compared with the case where a planar recess is formed.

Description will be given below on the present invention referring to the attached drawings.

Fig. 1 is a perspective view of a sealed battery of the present invention, showing inner structure of a battery case in through-vision view;

In a sealed battery 1 of the present invention, a positive electrode and a negative electrode are laminated on each other with a separator interposed between them in a rectangular type battery case 2, and these are wound up in flat shape. Then, this is pressurized to have flat shape to match the shape of the battery case, and a battery element 3 is prepared. Then, this is accommodated in the battery case. A current collecting tab 4 from one of the electrodes is connected to a current leading terminal 6 provided on a top cover 5 of the battery case. Another current collecting tab 7 from the other electrode is connected to an inner surface 8 of the battery case.

On a side surface 9 of the battery case running in parallel to the flat surface of the battery element, a curved recess 10 is formed. The curved recess has its central axis running in parallel to a flat surface on the side of the battery case and is formed on a surface passing through the center of the battery case and running perpendicularly to a flat surface of the battery element, i.e. a surface running perpendicularly to the side surface



9 of the battery case, and it has a concave surface depressed toward the inner part of the battery case.

In the sealed battery of the present invention, the central portion of the flat surface of the battery element  
5 is swollen or expanded at the most when the battery is charged. According to the present invention, such swelling or expansion of the battery element can be suppressed or prevented because the swelling or expanding surface is pressed against convex portion of the curved  
10 surface provided on the side surface of the battery case.

It is preferable that the curved surface is provided at the center of the side surface 9 of the battery case positioned in parallel to the flat surface of the battery case as in the present invention.

15 The depth from the side surface 9 of the battery case in parallel to the flat surface to the deepest portion (the most depressed portion) of the curved surface can be adjusted by selecting the size of the battery case or thickness of a metal material of the battery case.

20 Fig. 2 is a perspective view to explain another example of the sealed battery of the present invention.

A recessed portion 10 with curved surface is formed on the side surface 9 of the battery case positioned in parallel to the flat surface of the battery element in the  
25 sealed battery 1. The recessed portion 10 comprises a curved surface, which has a central axis running in parallel to the flat surface on outer side of the battery case. It is on a surface passing through the center of

the battery case and positioned perpendicularly to the flat surface of the battery element, i.e. a surface perpendicular to the side surface of the battery case. It has a curved surface depressed toward the inner part of the battery case.

A wall surface perpendicular to the surface 9 of the battery case is formed by the end of the recessed portion with curved surface positioned on an opening of the battery case and the side surface 9 of the battery case. A distance from this wall surface to an end of the opening of the battery case is reduced toward the center, i.e. this wall surface is formed as an arcuate curved surface 11.

The closer the arcuate curved surface 11 is positioned to the upper opening end of the battery case, the more the effect is obtained to suppress the swelling or expansion of the battery case. When a current collecting tab connected to the battery element is connected to the inner wall surface of the battery case, it is difficult to connect by welding if the connecting portion is in form of curved surface, and the connecting portion must be designed as a flat surface. For this reason, it must be in such size that a flat surface serving as the connecting portion can be maintained.

In the following, description will be given on embodiments of the present invention.

(Example 1)

A soft steel plate in the size of 64.5 x 22 x 6.3 mm (height x length x width) and in thickness of 0.35 mm was

processed by nickel plating. On a side surface of a battery case, which is made of this soft steel plate, a curved recess with a depth of 1.5 mm was formed. As shown in Fig. 3, the lower end of the recessed portion was at a distance of 3.0 mm from the bottom of the battery case, and the upper end of the recessed portion was at a distance of 5.5 mm from the upper opening of the battery case. An arcuate wall surface was formed from a position at 5.5 mm from the upper opening of the battery case to a position at 3.0 mm from the upper opening end. The central axis of the curved surface is on the surface, which has the central axis running perpendicularly to the side surface with the larger surface area.

A mixture comprising 92 weight parts of lithium manganate ( $\text{Li}_{1+x}\text{Mn}_{2-x}\text{O}_4$ ) powder, 5 weight parts of carbon black, and 3 weight parts of vinylidene polyfluoride was coated on an aluminum foil and was dried, and a positive electrode was prepared. A mixture comprising 91 weight parts of graphitized meso-carbon microbeads (MCMB; Osaka Gas Co., Ltd.), 1 weight part of carbon black, and 8 weight parts of vinylidene polyfluoride was coated on a copper foil and was dried, and a negative electrode was prepared. Separators made of fine porous polypropylene film were placed on both surfaces of the negative electrode, and both electrodes were wound up together in spiral form so that the negative electrode is exposed to outside, and the battery element thus prepared was accommodated in the battery case.

In a mixed solvent comprising 30 volume parts of ethylene carbonate and 70 volume parts of diethyl carbonate,  $\text{LiPF}_6$  was dissolved to have concentration of 1.0 mol/l, and an electrolytic solution was prepared. This electrolytic  
5 solution was injected into the battery case, and a lithium ion secondary battery was prepared.

On each of 20 secondary batteries thus prepared, measurement was made on thickness at the center of the battery and thickness at the uppermost position where the  
10 upper curved surface of the battery case and the side surface of the battery case were joined together. Average values calculated from the measured values are shown in Fig. 4.

(Example 2)

15 Batteries were prepared by the same procedure as in Example 1 except that an arcuate wall surface was not provided near the opening of the curved surface and a horizontal wall surface was disposed at the bottom of the battery case in the same manner as near the case bottom.  
20 Measurement was made on thickness of each battery case by the same procedure as in Example 1. The results are shown in Fig. 4.

(Comparative example 1)

A sealed battery was prepared by the same procedure as  
25 in Example 1 except that the recessed portion was not formed on the side surface. The results of measurement are shown in Fig. 4.

(Comparative example 2)

A sealed battery was prepared by the same procedure as in Example 1 except that a recessed portion in planar shape was formed with its bottom positioned at a depth of 1.5 mm from the side surface instead of the recessed portion in curved surface. The results of the measurement are shown in Fig. 4.

(Example 3)

A concave surface was formed in the same manner as in Example 1 except that the distance from the opening of the battery case to the uppermost end of the arcuate form was changed to 5 mm, 3.5 mm and 2.0 mm respectively, and thickness of each battery case was measured. The results are shown in Fig. 5. From these results, it was found that the shorter the distance to the uppermost end was, the thinner the thickness of the battery case at the uppermost part of the curved surface was.

As described above, by forming a recessed portion in form of a curved surface on the side surface of the battery case, swelling or expansion of the battery case can be suppressed when the battery is charged, and thickness of the battery case can be maintained within a predetermined limit.

WHAT IS CLAIMED IS:

1. A sealed battery, accommodating a battery element of flat shape, said battery element comprising a positive electrode and a negative electrode being laminated on each other with a separator interposed between them and being wound together, characterized in that a recessed portion is formed on a side surface of a battery case running in parallel to a flat surface of the battery element, said recessed portion having a central axis running in parallel to said flat surface and being positioned on a surface passing through the center of the battery case and running perpendicularly to the surface in parallel to the flat surface of the battery element.

2. A sealed battery according to claim 1, wherein said battery is a lithium ion battery.

3. A sealed battery according to claim 1, wherein a vertical wall surface is designed in form of a small curved surface, and said wall surface connecting an end of the recessed portion in form of curved surface on an opening of the battery case with a side surface in parallel to the flat surface of the battery element in the battery case, and a distance from the wall surface to the opening end of the battery is gradually reduced toward the center.

4. A sealed battery according to claim 3, wherein said battery is a lithium ion battery.

# ABSTRACT OF THE DISCLOSURE

The present invention provides a battery, in which swelling or expansion of side surface of a battery case when the battery is charged is reduced. The invention

5 provides a sealed battery, accommodating a battery element of flat shape, said battery element comprising a positive electrode and a negative electrode being laminated on each other with a separator interposed between them and being wound together, characterized in that a recessed portion is

10 formed on a side surface of a battery case running in parallel to a flat surface of the battery element, said recessed portion having a central axis running in parallel to said flat surface and being positioned on a surface passing through the center of the battery case and running

15 perpendicularly to the surface in parallel to the flat surface of the battery element.

FIG. 1

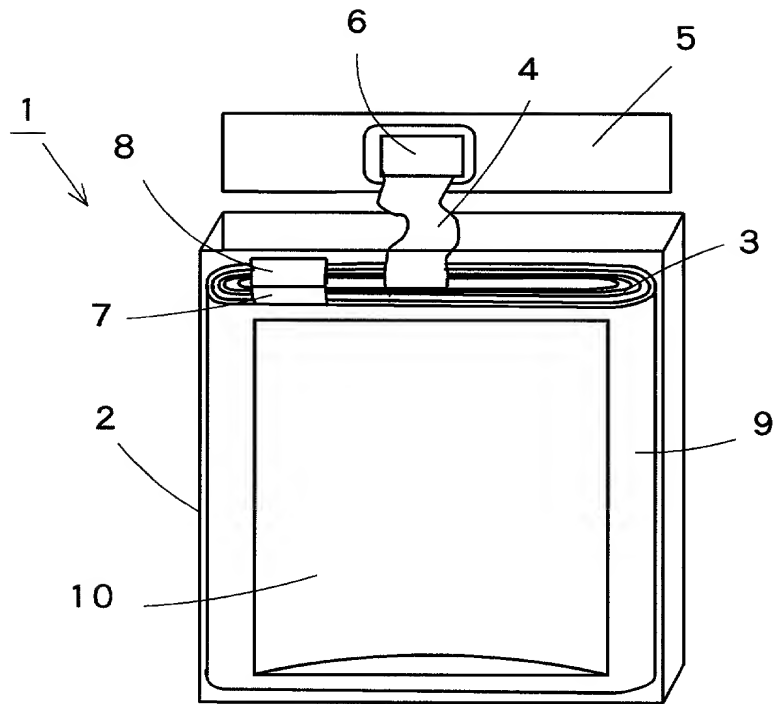


FIG. 2

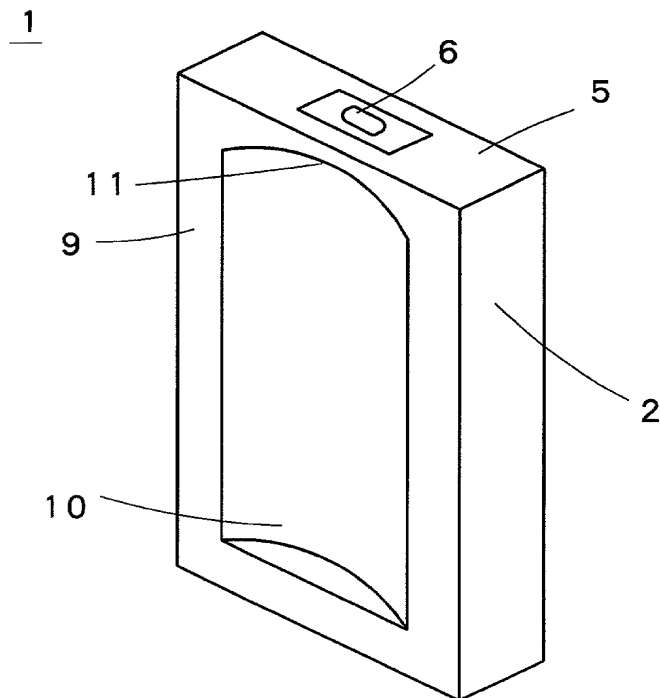




FIG. 3

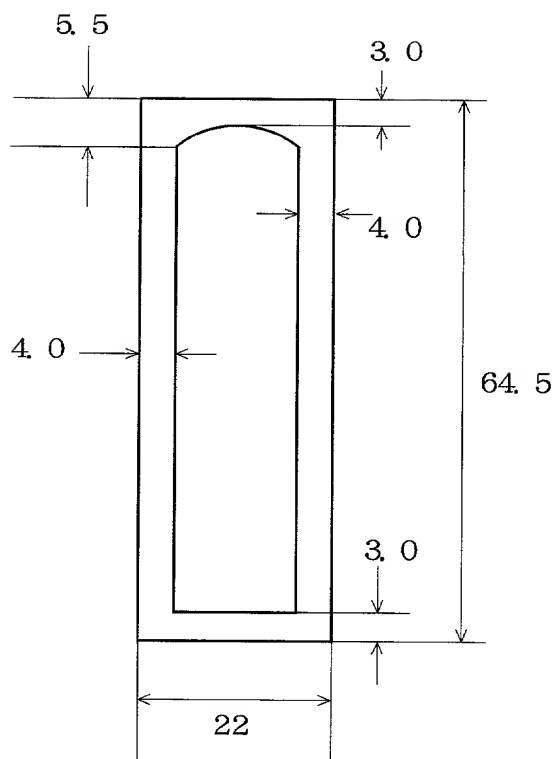


FIG. 4

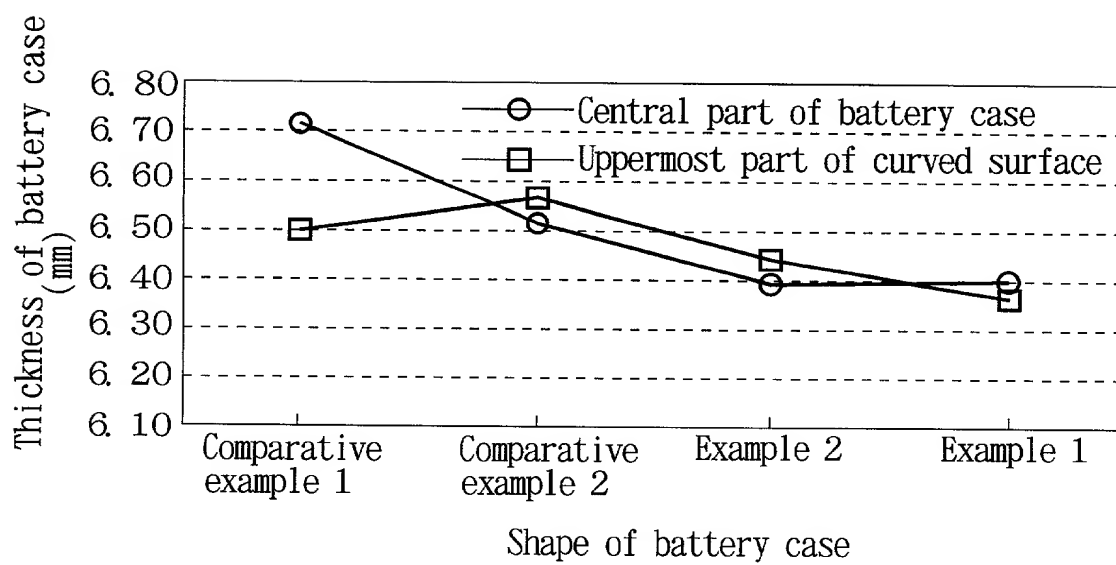
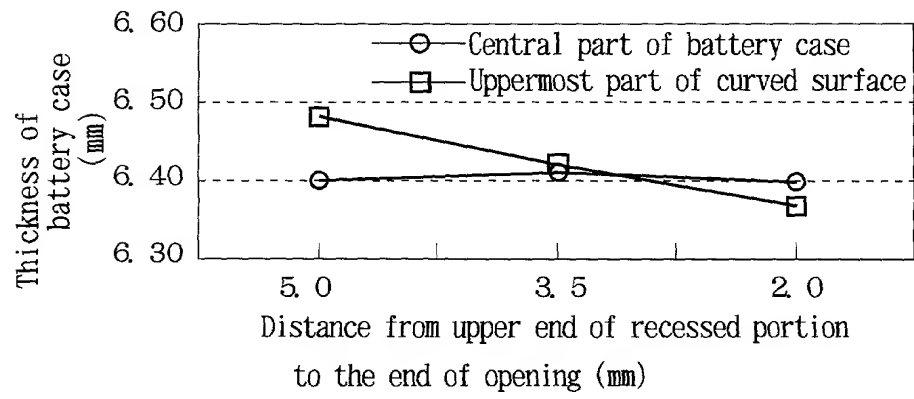


FIG. 5



**Declaration For U.S. Patent Application**1113-57  
(11/19/99-45)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention **entitled**  
(Insert Title) \_\_\_\_\_**SEALED BATTERY**

the specification of which is attached hereto unless the following is checked:

was filed on \_\_\_\_\_ as United States Application Number or PCT International  
Application Number \_\_\_\_\_ and was amended on \_\_\_\_\_  
(if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 (a) - (d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

(List prior  
foreign  
applications.  
See note A  
on back of  
this page)

11-333646	Japan	25/11/99	Priority Claimed <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
(Number)	(Country)	(Day/Month/Year Filed)	
(Number)	(Country)	(Day/Month/Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No
(Number)	(Country)	(Day/Month/Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No
(Number)	(Country)	(Day/Month/Year Filed)	<input type="checkbox"/> Yes <input type="checkbox"/> No

(See note B on back of this page)

☐ See attached list for additional prior foreign applications

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

(Application Number)	(Filing Date)
(Application Number)	(Filing Date)

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of the application:

(List Prior U.S. Applications)	(Application Serial Number)	(Filing Date)	(Status) (patented, pending, abandoned)
	(Application Serial Number)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

James E. Armstrong, III, Reg. No. 18,366; William F. Westerman, Reg. No. 29,988; Ken-Ichi Hattori, Reg. No. 32,861; Le-Nhung McLeland, Reg. No. 31,541; Ronald F. Naughton, Reg. No. 24,616; John R. Pegan, Reg. No. 18,069; William G. Kratz, Jr., Reg. No. 22,631; Albert Tockman, Reg. No. 19,722; Mel R. Quintos, Reg. No. 31,898; Donald W. Hanson, Reg. No. 27,133; Stephen G. Adrian, Reg. No. 32,878; William L. Brooks, Reg. No. 34,129; John F. Carney, Reg. No. 20,276; Edward F. Welsh, Reg. No. 22,455; Patrick D. Muir, Reg. No. 37,403; Gay A. Spahn, Reg. No. 34,978; and John P. Kong, Reg. No. 40,054.

Please direct all communications to the following address: ARMSTRONG, WESTERMAN, HATTORI,  
McLELAND & NAUGHTON  
1725 K Street, N.W., Suite 1000  
Washington, D.C. 20006  
Telephone: (202) 659-2930 Fax: (202) 887-0357

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18 of the United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor (given name, family name) Tsutomu OOSHIMA  
(See note C above) Inventor's Signature Tsutomu Ooshima Date October 2, 2000  
Residence Same as post-office address Citizenship Japan  
Post Office Address C/O NEC MOBILE ENERGY CORPORATION, 484, Harigaya-Cho,  
Utsunomiya-Shi, TOCHIGI 321-0147 JAPAN

Full name of second inventor (given name, family name) \_\_\_\_\_  
Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
Post Office Address \_\_\_\_\_

Full name of third inventor (given name, family name) \_\_\_\_\_  
Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
Post Office Address \_\_\_\_\_

Full name of fourth inventor (given name, family name) \_\_\_\_\_  
Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
Post Office Address \_\_\_\_\_

Full name of fifth inventor (given name, family name) \_\_\_\_\_  
Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
Post Office Address \_\_\_\_\_

Full name of sixth inventor (given name, family name) \_\_\_\_\_  
Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
Post Office Address \_\_\_\_\_

Full name of seventh inventor (given name, family name) \_\_\_\_\_  
Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
Post Office Address \_\_\_\_\_

Full name of eighth inventor (given name, family name) \_\_\_\_\_  
Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_  
Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
Post Office Address \_\_\_\_\_